

# Value of postprocedural chest radiographs in the adult intensive care unit

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**Objective:** To evaluate the necessity for postprocedural chest radiographs after catheterization of central veins, insertion of pulmonary artery catheters, and placement of endotracheal tubes.

**Design:** Prospective, controlled study.

**Setting:** Two academic tertiary adult ICUs.

**Patients:** Consecutive patients (n = 316) requiring central vein cannulation or endotracheal intubation in the ICUs.

**Intervention:** After each invasive procedure, the physician was instructed to complete a detailed evaluation sheet. Criteria based on the details of the procedure and immediate postprocedural clinical evaluation of the patient were used to determine the likelihood of a radiologically detectable complication. Actual radiologic findings were subsequently compared against clinical predictions.

**Main Outcome Measurements:** Ability of housestaff to correctly predict the absence of radiologically detectable postprocedural complications (predictive negatives).

**Results:** Ability to predict the absence of complications after cordis catheter insertions via the subclavian vein or internal jugular vein was very high (151/152;  $p < .001$ ). Unsuspected complications were more frequent with central vein multilumen catheter insertions (3/24;  $p < .001$ ). Ability to predict uncomplicated pulmonary artery catheterization was also high (110/111;  $p < .001$ ). Physicians were unable to predict the majority of complications associated with endotracheal intubations (28/32;  $p > .50$ ).

**Conclusions:** The use of a protocol that includes an evaluation of the characteristics of the procedure and postprocedural physical

examination can greatly reduce the need for routine chest radiographs after subclavian and internal jugular vein cordis catheterizations and pulmonary artery catheter placement. Chest radiographs should be performed after endotracheal intubation and multilumen catheter insertion. (Crit Care Med 1992; 20:1513-1518)

**KEY WORDS:** complications; intensive care; catheterization, pulmonary artery; intubation, endotracheal; catheterization, central venous; cost containment; radiography; critical illness; pulmonary emergencies; radiology

Historically, patients in the adult ICUs at our institution have undergone the performance of mandatory sitting or supine chest radiographs after endotracheal intubations, insertion of pulmonary artery catheters, chest tubes, and all cannulations of subclavian and internal jugular veins. These invasive procedures are performed by intensive care fellows, interns, and residents from surgery, anesthesia, and medicine services who are rotating through the ICUs.

Chest radiographs have been recommended to verify placement of intrathoracic venous infusion catheters, pulmonary artery catheters, and endotracheal intubations (1-4). The value of such routine films has been previously assessed only in patients undergoing endotracheal intubation (5). We prospectively evaluated the usefulness of routine postprocedural chest radiographs in the adult medical and surgical ICUs.

We hypothesized that housestaff could correctly predict the absence of radiologically detectable postprocedural complications. To test this hypothesis, we compared clinical predictions against actual radiologic findings.

## MATERIALS AND METHODS

The need for informed consent was waived by the University of Manitoba ethics committee.

During a 9-month period from April 1989 to December 1989, all housestaff assigned to the adult

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This study was supported, in part, by the Manitoba Health Services Commission.

0090-3493/92/2011-1513\$03.00/0

medical and surgical ICUs at our institution were instructed to complete a detailed data form (Appendix) immediately after completion of the following procedures: a) endotracheal intubation; b) pulmonary artery catheter insertion; c) insertion of cordis and multilumen catheters via internal jugular or subclavian veins; and d) temporary pacemaker insertion.

Data on the form included details with respect to the specific procedure, and relevant positive physical findings indicative of potential complications related to the procedure(s). Housestaff were directed to indicate on the form if no complications were suspected ("routine" findings on the radiographs). If a complication was suspected after completion of the procedure and evaluation of the patient, including physical examination, specific criteria included on the sheet were checked off, and the suspected complication was identified. In all cases, and following completion of the data form, a supine or sitting chest radiograph was then performed. The study number on the completed data form was transcribed by the ward clerk to the subsequent chest radiograph. All radiographs were randomly and independently interpreted by a staff chest radiologist with specific reference to the identification or exclusion of radiologically identifiable postprocedural complications as listed on the data form (Appendix).

Sensitivity, specificity, and positive and negative predictive values were then calculated for each procedure. Statistical significance was assessed using the chi-square test for each procedure.

## RESULTS

During the study period, 316 data sheets were submitted, of which eight were incomplete. The details of 457 separate procedures described in the remaining 308 forms are presented in Table 1.

Four procedures were performed frequently enough to allow analysis. These procedures included 112 endotracheal intubations, 47 subclavian vein cannulations, 147 internal jugular vein cannulations, and 132 pulmonary artery catheter insertions. Table 2 describes our results with respect to endotracheal intubation. Of the 112 endotracheal intubations, 106 were predicted to be uncomplicated before examination of the postprocedural radiograph. Of these 106 cases, 28 were judged by the radiologist to be malpositioned according to the criteria provided in the Appendix. The six remaining intubations were predicted to be complicated by malpositioning before radiographic interpretation and malpositioning was confirmed subsequently on radiograph in four of the six cases. The only serious complication was a right main stem bronchial intubation leading to a collapsed left lung, and this event was suspected

**Table 1.** Description of procedures

Procedure	Total
Central Venous Catheter	
Internal jugular vein	147
Subclavian vein	47
Pulmonary artery catheter placement	132
Endotracheal intubation	112
Chest tube	4
Temporary pacemaker	9
Tracheostomy	2
Tunnelled, cuffed catheter	4
Total	457

**Table 2.** Predicted vs. actual complications after endotracheal intubation (n = 112)

	No Complication	Complication Present	Predicted (%)
Complication not suspected	78	28	73.6 negative
Complication suspected	2	4	66.7 positive
	95.7% Specificity	12.5% Sensitivity	

Chi-square not significant after Bonferroni correction.

based on physical findings evident immediately after the intubation. All unsuspected complications subsequently identified on chest radiograph are shown in Table 3.

Table 4 describes our results after internal jugular vein cannulation. Of the 147 catheterizations performed, 135 were predicted to be associated with no complications. Only one unsuspected complication was identified, and this complication consisted of advancement of a cordis catheter into the ipsilateral axillary vein (Table 3).

In the remaining 12 cases where complications were suspected, three were identified, including two pneumothoraces and one multilumen catheter advanced into the right atrium.

Of the 132 pulmonary artery catheter insertions, 111 were predicted to be uncomplicated (Table 5). In one case, the tip of the pulmonary artery catheter appeared to be in the right ventricular outflow tract, just below the pulmonic valve. In the remaining 21 cases where complications were suspected, 12 were identified and consisted of eight catheters looped in the right ventricle with appropriate tip position, one catheter in the right ventricular outflow tract, one catheter tip in an internal mammary vein, and two pulmonary artery catheters inserted >10 cm below the carina. The latter two pulmonary artery catheter insertions were associated with dampened pulmonary artery tracings.

**Table 3.** Description of all clinically unsuspected but radiologically detected complications (n = 33)

Procedure	Complication	No.
IJV	Cordis in left axillary vein	1
SCV	Multilumen catheter malposition	3
PACP	Right ventricular outflow tract	1
ET	Right mainstem	6
ET	<4 cm above carina	21
ET	At thoracic inlet	1

IJV, internal jugular vein catheterization; SCV, subclavian vein catheterization; PACP, pulmonary artery catheter; ET, endotracheal intubation.

**Table 4.** Predicted vs. actual complications after internal jugular vein cannulation (n = 147)

	No Complication	Complication Present	Predicted (%)
Complication not suspected	134	1	99.3 negative
Complication suspected	9	3	25.0 positive
	93.7% Specificity	75.0% Sensitivity	

Chi-square  $p < .001$ .

**Table 5.** Predicted vs. actual complications after pulmonary artery catheterization (n = 132)

	No Complication	Complication Present	Predicted (%)
Complication not suspected	110	1	99.1 negative
Complication suspected	9	12	57.1 positive
	92.4% Specificity	92.3% Sensitivity	

Chi-square  $p < .001$ .

Of the 47 subclavian vein cannulations (Table 6), 41 were predicted to be uncomplicated. In three cases, multilumen catheter tips were identified in the ipsilateral jugular vein, in the contralateral subclavian vein, and in the right atrium, respectively. In the remaining six subclavian vein cannulations where complications were suspected, four multilumen catheter tip malpositions were identified and a suspected pneumothorax was confirmed.

Only one unsuspected catheter malposition was identified with cordis catheter insertions (n = 152) in subclavian veins or internal jugular veins. Unsuspected catheter tip malposition was more frequent (3/24;  $p < .001$ ) with central vein, multilumen catheter insertions.

**Table 6.** Predicted vs. actual complications after subclavian vein catheterization (n = 47)

	No Complication	Complication Present	Predicted (%)
Complication not suspected	38	3	92.7 negative
Complication suspected	1	5	83.3 positive
	97.4% Specificity	62.5% Sensitivity	

Chi-square  $p < .001$ .

Of the 194 patients undergoing central venous catheterization, the following was found: 141 (72.7%) patients were intubated and mechanically ventilated using positive pressure; three (1.5%) were intubated but not mechanically ventilated; 41 (21.1%) were not intubated; and in nine (4.6%) patients, the ventilatory status could not be determined.

## DISCUSSION

The overall complication rates observed in our study included the following: 6% (12/194) for central venous infusion catheter insertions via the internal jugular and subclavian veins; 10% (13/132) for pulmonary artery catheter placement; and 29% (32/112) for endotracheal intubations. These results, which represent only the complications detected on chest radiographs, are similar to the results of previous reports (4-9).

Our observations support the need for routine radiographs after endotracheal intubation to confirm position. Our housestaff were unable to reliably predict an uncomplicated endotracheal intubation. Our radiologic criteria defining acceptable endotracheal tube position adopted from Conrardy et al. (10) may have been too rigorous, as they described "ideal" rather than acceptable tube position. As previously suggested by Owen and Cheney (6), we referenced the measurements printed on the tube to assess positioning before radiograph confirmation. Despite similar results, we cannot advocate discontinuation of the postprocedural radiographs. None of the unsuspected complications produced adverse effects. Since endotracheal tubes were subsequently advanced or retracted in many cases in which malposition was initially unsuspected, it cannot be assumed that serious morbidity would not have resulted had chest radiographs been omitted.

It is clear from our observations that housestaff were able to accurately predict the absence of complications after insertion of cordis and pulmonary artery catheters (261/263 procedures). Neither of the two unsuspected complications were clinically important and all

potentially harmful complications, including pneumothoraces and looped pulmonary artery catheters, were predicted. Concern has been frequently expressed about distal placement of the pulmonary artery catheter tip and the risk of pulmonary artery rupture and infarction. There are few data in the literature to support these associations. Hardy et al. (11) demonstrated that rupture pressures in the midpulmonary artery were lower than in the distal vessels. The presence of pulmonary hypertension or coagulopathy may also increase the risk of hemorrhage (12, 13). No pulmonary infarctions or hemorrhages resulted from pulmonary artery catheter insertions during this study.

Subclavian vein cannulations were associated with three unsuspected multilumen catheter tip malpositions. Four other cases of malpositioning were suspected and the only pneumothorax was predicted.

Several investigators (14–16) evaluated the efficacy of daily routine chest radiographs in ICU patients. Our study focused exclusively on routine postprocedural chest radiographs.

The expertise of the housestaff in performing the procedures was variable. More than half of the procedures were performed by junior residents and interns during their initial exposure to ICUs and it is, therefore, unlikely that our results reflect a higher than usual level of expertise among our housestaff in comparison with other centers. The study protocol required individual documentation by the housestaff of the details of the procedures, a mandatory review of potential complications from the data sheets immediately after the procedure, and mandatory physical examination of the patient, including review of hemodynamic and respiratory variables that might be altered after a complication. Such a regimented approach may have compensated for the lack of experience of junior house officers and contributed to the high rate of accuracy in predicting uncomplicated procedures involving central venous catheter placement. Therefore, elimination of routine postprocedural chest radiographs without continuation of the above-mentioned diagnostic protocol may result in unsuspected complications and morbidity.

It might be argued that a large volume of unnecessary radiographs could be justified, if even a rare occurrence of life-threatening complication were detected. However, this assertion may be simplistic for several reasons. Life-threatening complications (e.g., tension pneumothorax) can often be detected, or at least suspected, by clinical parameters before routine radiographs. There may also be adverse effects related to false-positive interpretation of unnecessary radiographs. In the year before our study, chest tubes were inserted in two patients due to subsequently unconfirmed radiographic suspicion of pneumothoraces by junior housestaff. One procedure resulted in an

empyema and the second in hemorrhage requiring transfusion. In the past, considerable delays were routinely incurred after pulmonary artery catheter insertions because of the insistence of nursing staff to confirm position of the catheter tip by chest radiograph before performing cardiac output determinations. We feel that in most cases this approach is unnecessary.

In the 6 months after termination of our study, we observed an overall 24% reduction in chest radiographs when adjusted per patient day. We recorded no instance of an unanticipated clinically important postprocedural complication after a central vein cordis catheter insertion or pulmonary artery catheter insertion. However, we continue to routinely perform radiographs after endotracheal intubation and insertion of multilumen catheters.

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## APPENDIX

**MEDICAL/SURGICAL ICU**  
**POSTPROCEDURAL RECORD**

Patient ID Stamp

PLEASE CHECK ALL THAT APPLY.

VENOUS ACCESS    ☐ Internal jugular    ☐ Subclavian    ☐ Right    ☐ Left    ☐ Other  
 CATHETER TYPE    ☐ Cordis    ☐ Triple lumen    ☐ Dialysis    ☐ Other  
 SWAN-GANZ    ☐ Inserted at the same time as cordis insertion *or*  
                   ☐ Inserted into preexisting cordis  
                   ☐ Endotracheal type  
 PACEMAKER    ☐

☐ No complication suspected; routine radiograph☐ PNEUMOTHORAX:

<input type="checkbox"/> unexpected chest pain	<input type="checkbox"/> shortness of breath	
<input type="checkbox"/> increased respiratory rate	<input type="checkbox"/> hyper-resonance	
<input type="checkbox"/> decreased hemithoracic excursion or	<input type="checkbox"/> breath sounds	
<input type="checkbox"/> tracheal deviation	<input type="checkbox"/> increased jugular venous pressure	<input type="checkbox"/> decreased BP
<input type="checkbox"/> pulsus paradoxus	<input type="checkbox"/> increased heart rate	
<input type="checkbox"/> aspirated air into syringe		

☐ PULMONARY ARTERY RUPTURE:☐ hemoptysis☐ CARDIAC TAMPONADE:

<input type="checkbox"/> decreased BP	<input type="checkbox"/> increased heart rate	
<input type="checkbox"/> increased jugular venous pressure	<input type="checkbox"/> pulsus paradoxus	<input type="checkbox"/> muffled heart sounds

☐ CATHETER MALPOSITION:

<input type="checkbox"/> neck, <input type="checkbox"/> ear, <input type="checkbox"/> or arm pain	<input type="checkbox"/> poor blood return
<input type="checkbox"/> intravenous fluids not flowing freely	
<input type="checkbox"/> 20-cm, multilumen catheter with right-sided approach	

PULMONARY ARTERY CATHETER MALPOSITION:

<input type="checkbox"/> poor right ventricle, pulmonary artery, or wedge tracing
<input type="checkbox"/> resistance during advancement or withdrawal
<input type="checkbox"/> length inserted >60 cm at cordis with right-sided approach
<input type="checkbox"/> balloon volume for wedge <1.25 mL

☐ ENDOTRACHEAL TUBE MALPOSITION:

<input type="checkbox"/> male, >24 cm at lips	<input type="checkbox"/> female, >22 cm at lips
<input type="checkbox"/> unequal breath sounds	<input type="checkbox"/> excessive coughing

☐ OTHER: Please specify

Signature\_\_\_\_\_

Date\_\_\_\_\_

## INTERVENTION

## RADIOGRAPHIC INTERPRETATION: (For radiologist only)

☐ No significant procedure-related abnormality

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☐ Pneumothorax

☐ Hematoma

☐ Catheter tip location<sup>a</sup>

- ☐ in right atrium
  - ☐ in "too far": >10 cm from midline; >10 cm below carina
  - ☐ in axillary vein
  - ☐ in internal jugular vein, cephalic orientation
  - ☐ through right ventricular wall
  - ☐ other \_\_\_\_\_
- 

☐ Looped

☐ Infiltrate distal to/at tip

☐ Oligemia beyond tip

☐ Endotracheal location

- ☐ above cords
- ☐ <4 cm above carina
- ☐ right main stem
- ☐ left main stem

COMMENTS: \_\_\_\_\_

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<sup>a</sup>Acceptable position for multilumen catheter tip is the superior vena cava.